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CONSUMER BENEFITS FROM NEW RICE VARIETIES IN THE PHILIPPINES

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Preface

Several term papers prepared by graduate students enrolled in Agricultural and Applied Economics 8-264 in the Fall of 1973 were of excellent quality. Because of their value to students of resource economics problems, several of these are being issued in the Staff Paper Series of the Department of Agricultural and Applied Economics.

This paper by Donato B. Antiporta provides an excellent example of an effort to use welfare economics to measure consumer and producer benefits of a technological change, improved new varieties of rice in the Philippines. The first paper in this particular series, Staff Paper P74-9a was Maurice Mandale, Multiple Use of Wild Land: A Review of the Policy and the Concept, issued in September 1974.

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CONSUMER BENEFITS FROM NEW RICE VARIETIES IN THE PHILIPPINES

Donato B. Antiporta

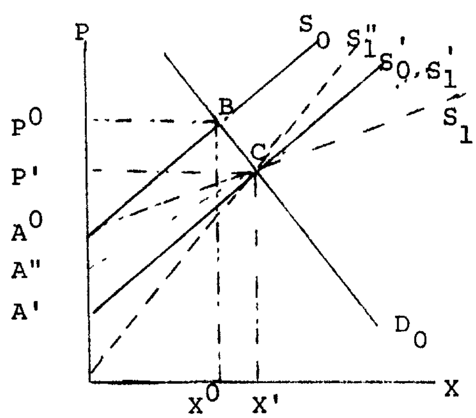
1. Scope of the Paper

This paper is an exploration into the measurement of the social benefits from new technology -- new varieties of rice -- in the Philippines. As with most developing countries, the Philippines is faced with a scarcity of resources for agricultural development. Economic logic dictates that policies involving public fund expenditures should be guided by the social costs and benefits associated with the different alternative programs. If accurate measures of these social costs and gains cannot be obtained, it is at least desirable to indicate the effects of the program on the different sectors of the economy. To say that the results reported here could guide decision makers in the Philippines is perhaps an overstatement since the analysis is made primarily in a partial equilibrium framework. However the methodological issues raised in the paper may be of interest to those who want to analyze similar problems or who wish to do a more rigorous analysis of the same problem.

This paper analyzes the gains from the new varieties of rice and estimates how these benefits are distributed between producers and consumers, as well as within each group. The analysis of the distribution of the benefits among individual producers is restricted to a theoretical frame due to the unavailability of data. The paper attempts an empirical measurement of the benefits to consumers in different income categories and offers brief comments on the concepts of consumer surplus and compensating variation in income. For want of sufficient data, nothing is said here about the cost of varietal development except to note that the innovation involved no research expenditures by the private domestic sector.

2. Consumer Gains Versus Producer Gains

The direct social benefits from a change in the price of rice consist of gains by consumers and producers. Consider the following aggregate demand and supply curves for rice:



As technology shifts the supply curve to the right, price falls from P^0 to P' and consumers as a group gain the area P^0BCP'.[1/] This gain is unambiguously positive. In comparison, the gain of the producers depends upon the nature of the shift in the supply curve. If the

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1/ Aside from the usual aggregation problems, the validity of this measure of consumer gain is examined below.

supply curve has shifted in a parallel way from S_0 to S'_0, the producers' gain is equal to the difference between P'CA' and P^0BA^0.2/ This difference is positive as long as the demand curve is downwardly sloping and not vertical. The gain of producers will be even greater if the supply curve has shifted from S_0 to S''_1. If the shift in the supply curve affects the slope but not the intercept, say from S_0 to S_1, the producers' gain will be negative if the demand for rice is price inelastic. That is,

$$\tfrac{1}{2}X^0 \ (P^0 - A^0) - \tfrac{1}{2}X' \ (P' - A^0) > 0$$
$$(X^0P^0 - X'P') + A^0 \ (X' - X^0) > 0$$

as long as the price elasticity of demand is less than unity. If supply has shifted from S_0 to S'_1, the gain of the producers is of indeterminate sign:

$$\tfrac{1}{2}(P^0 - A^0)X^0 - \tfrac{1}{2}(P' - A'')X' \gtrless 0$$
$$(X^0P^0 - X'P') + (X'A'' - X^0A^0) \gtrless 0$$

Given a price inelastic demand for rice, the first group of terms is positive while the second group of terms is negative. Thus, the gain of the producers from the price change might be positive or negative.

2/ This is the difference between producer's surplus in the initial and in the new situation. The term "producer's surplus" refers to the wider interpretation of the concept; i.e., the surplus which accrues to the owners of the factors rather than to the owner (operator) of the firm. The area measures the Ricardian rent to land if all other factors of production are available at constant prices (3, pp. 754-757).

Lack of sufficient information on the nature of the shift in supply resulting from the development of the high yielding varieties of rice precludes the measurement of the benefits to the producers. Consequently, the question of relative benefits between the two broad groups of the consumers and the producers cannot be resolved in the present paper. The preceding analysis suggests that consumer benefits are definitely positive and that the change in producer's surplus may be positive or negative.

A rising industry supply curve reflects the differences in the characteristics of the fixed factors such that higher quality farms operate with lower average costs. And the effects of new seeds on the intensity of the variable input use tends to be greater on farms with the higher quality fixed factors. The full realization of the yield potential of the new rice seeds depends upon a corresponding increment in the use of inputs like fertilizer, insecticides, irrigation, herbicides, etc. Available farm data indicate that at low levels of these inputs the yield advantage of the new varieties is not substantial. This implies that if all producers switched to the new rice its effect would be to shift the supply curve from S_0 to S_1''. Thus, there is a strong reason for believeing that producers as a group derive some benefits from the seed technology.

3. Distribution of Benefits within the Producing Sector[3/]

Individual benefits to producers are determined by the firm's supply curve before and after the introduction of the new seeds. Adoption of

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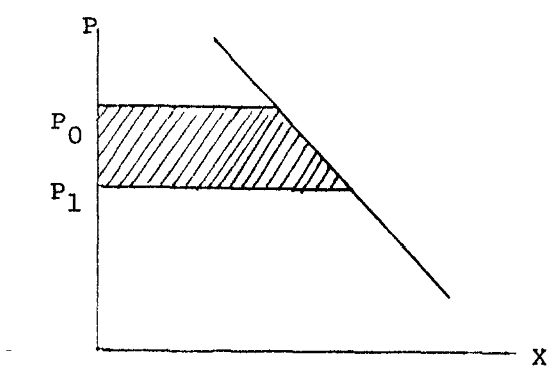
3/ In this section no explicit distinction is made between owners of factors and owners (operators) of firms. A distinction between the two would be necessary if the analysis focused on the distribution of factor incomes.

new varieties may be restricted by physical and economic factors on some farms. Producers in this class stand to lose since no increase in productive efficiency offsets the fall in the price of rice. Those producers who adopt the new seeds can benefit provided the firm's supply curve shifts far enough to compensate for the fall in price. The extent to which productive efficiency improves depends upon the quality of land and water management, efficiency in the use of variable inputs like fertilizer, insecticides, etc., and/or environmental factors. Therefore better farms and better farmers will tend to have larger than average gains from the seed technology.

4. Consumer's Surplus and Compensating Variation

Given an ordinary demand curve as below:



Dupuit in 1884 held that the shaded area in the above diagram represents the monetary equivalent of the consumer's surplus or the utility gained by a consumer from a fall in price from P_0 to P_1. Marshall made the qualification that such a correspondence is true provided the marginal utility of money is constant (4, pp. 38-41). With some refinements in the terminology Samuelson analyzed the empirical implications of two alternative interpretations of the hypothesis about the constancy of the marginal utility of income. Three major conclusions arise from his analysis:

1) The marginal utility of income cannot possibly be independent of <u>all</u> prices and money income because demand functions are homogenous of degree zero.

2) The Marshallian hypothesis that the marginal utility of income is independent of all price changes but not of money income implies an empirical restriction that the income elasticity of demand is unity and expenditures on every good are proportional. The hypothesis of independent marginal utility of income can thus be rejected on the basis of numerous empirical budget studies and is incompatible with the data used in this paper.

3) A second interpretation of constant marginal utility of income is that it is independent of money income and all prices except one commodity which is designated as the <u>numeraire</u>. Likewise, this interpretation results in an implausible implication, i.e. increases in income will be spent completely on this one commodity (the <u>numeraire</u>).

It is clear that these conclusions are damaging to methodological constructs which rely upon the assumption of a constant marginal utility of income for validity. It is shown in the literature that constancy of the marginal utility of income is neither necessary nor sufficient for zero income effect (3, p. 751). It becomes tempting to save this consumer's surplus type of measure by replacing the assumption about the constancy of the marginal utility of income with another assumption about a zero income effect. But this alternative assumption becomes untenable in the case of rice in the Philippines. Rice is a major expenditure item for consumers and its income elasticity is greater than zero.

Compensating variation in income is one measure which does not rely on any assumptions about the marginal utility of income but which "... has informational requirement no greater than those of consumer's surplus type measures ... and may be employed ... to determine the money income which at its new price would yield the same utility as that derived from his actual money income at the original price. The difference between this utility constant income and his actual income provides a measure of change in his real income resulting from the price change..." (8, pp. 349-351).

Take a consumer with a utility function:

$$U = U(x_1, x_2, \ldots, x_n) \tag{1}$$

The total change in the utility level as a result of changing the price of x_1 is:

$$dU/dP_1 = \sum_{i=1}^{n} (\partial U/\partial x_i)(\partial x_i/\partial P_1) \tag{2}$$

The quantity $\partial x_i/\partial P_1$ embodies both the substitution and income effects of the change in P_1 on the quantities of the consumed commodities. From the first order condition of a rational utility maximizing consumer:

$$\partial U/\partial x_i = \lambda P_i \tag{3}$$

where λ is the marginal utility of income. From the budget constraint identity:

$$M = \sum_{i=1}^{n} P_i x_i$$

$$dM/dP_1 = x_1 + \sum_{i=1}^{n} P_i \, \partial x_i/\partial P_1 \qquad (4)$$

If the income (M) of the consumer is continually adjusted as to hold the consumer at a given level of utility, then from (2) and (3) :

$$\sum_{i=1}^{n} P_i \partial x_i/\partial P_1 = 0 \text{ for } \lambda \neq 0 \quad \text{(non-bliss point)}$$

and (4) becomes:

$$dM/dP_1 \Big|_{dU=0} = x_1 \qquad (5)$$

which suggests that

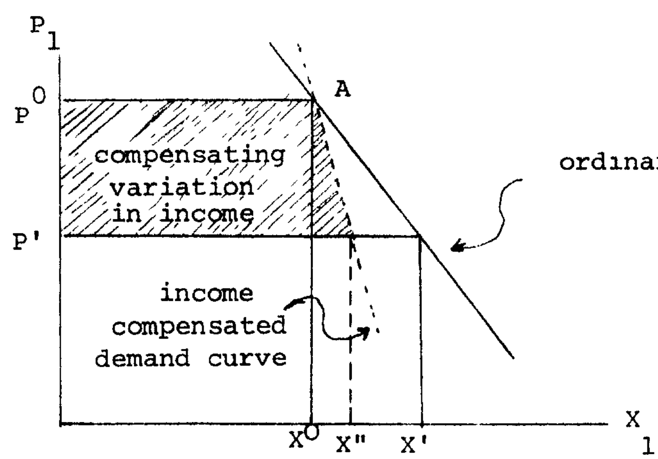
$$\Delta M = \int_{P^0}^{P'} x_1 dP_1 \text{ where } x_1 = x_1(P_1, M(P_1)) \qquad (6)$$

and ΔM is the amount which could be taken away from the consumer to leave him as well off at the new price situation as he was initially. Note that the result obtained above is free of any troublesome assumption about λ, an assumption which has plagued the Marshallian consumer's surplus. The only restriction implicit above is integration along the income-compensated rather than along the ordinary demand curve. This follows from the restriction that $M(P_1)$ must be adjusted continuously in response to changes in P_1 so as to keep the consumer on a given utility level

(8, p. 351; 3, pp. 747-749). Here lies the basic difference between the compensating variation measure and the consumer's surplus where money income instead of utility level is being held constant.

5. Measuring the Compensating Variation in Income

The Slutsky relations provide a useful link for deriving the compensated demand curve from the ordinary demand curve. Consider the following diagram:



The objective is to find the amount X" which the consumer would have bought at the new price P' if his original income M is adjusted as to leave him as well off as before when with income M he was consuming X^0 of the commodity at an initial price P^0. Once X" is known, the shaded area which represents the compensating variation in income can be estimated by linear approximation.

By appropriate algebraic manipulations the Slutsky equation can be stated as

$$e_{11} = E_{11} + a_1 n_1 \tag{7}$$

where

E_{11} is the price elasticity of demand for X_1 along the ordinary demand curve

e_{11} is the price elasticity of demand for X_1 along the income compensated demand curve

a_1 is the proportion of income spent on X_1, and

n_1 is the income elasticity of demand for X_1.

Given E_{11}, a_1, and n_1 then e_{11} can be obtained from equation (7). Together with an initial equilibrium point A the ratio of the two arc price elasticities

$$\frac{E_{11}}{e_{11}} = \frac{(X^0 - X')}{(X^0 + X')} \cdot \frac{(X^0 + X'')}{(X^0 - X'')} \qquad (8)$$

gives X" in terms of previously known quantities

$$X'' = \frac{X^0(E_{11}(X^0 + X') - e_{11}(X^0 - X'))}{E_{11}(X^0 + X') + e_{11}(X^0 - X')} \qquad (9)$$

6. Increase in Rice Production Due to the New Varieties

Complications arise in the measurement of the net increase in rice production and thus of the consumer benefits from the new varieties because of the following:

1) There is a lag in the adoption of the new high-yielding rice varieties by farmers. A separate analysis of village data reveals that in areas best suited to the new rice, the transition period is about five years from the date of introduction.

2) The price effects of increased production due to the new rice seeds are hardly observable and are concealed by the influences of inflation, population growth and similar phenomena that shift demand and price over time.

3) Some increments in rice production over time can be explained by hectarage expansion due to additional land brought into cultivation and to hectarage diverted from other crops to rice as well as by some improvement in existing hectarage through the provision of irrigation and drainage facilities, etc.

4) The performance of the new rice varieties under controlled (experimental) conditions may not truly reflect their productivity under actual field conditions. Further the effects of weather variability on the yield of indigenous rice compared with yield of the new varieties could possibly be asymmetrical.

5) The external effects of the development of the new rice primarily on employment, production and prices of substitute crops and on the agribusiness sector of the economy may be large.

Rather than attempt a rigorous econometric estimate of the net increase in supply due to the new rice varieties, I shall be content with an index-number approach. The estimated percentage shifts in rice production are summarized in Table 1. The date of introduction of the new varieties was deemed to be 1968. The percentage of the area of the new rice in 1972 was assumed as the equilibrium rate of adoption beyond 1972.[4/] It should be noted that estimates of the rates at which rice

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4/ The new varieties had not entirely displaced the traditional varieties as of 1972. This has certain implications for the accuracy of using total compensating variation as a measure of the benefits from the new rice. Discussion of this issue is postponed to a later section.

Table 1. Annual rates of adoption of the new varieties and estimated rates of increase in rice production in the Philippines.

YEAR	Percent of: Area in New: Rice:		Yield Differ-: ential: (cavans/ha.):		Increase in Rice Production: due to New Rice* (cavans)			Percent Increase**
	Irri-: gated:	Rain-: fed:	Irri-: gated:	Rain-: fed:	Irrigated:	Rainfed:	Total:	
1968	34.0	16.9	8.3	1.2	2,465,743	143,595	2,609,338	2.52
1969	61.6	31.2	3.6	1.2	4,467,214	264,530	4,731,744	4.56
1970	61.4	38.9	6.1	-.9	4,452,710	329,814	4,782,524	4.61
1971	67.0	45.4	2.1	-.8	4,858,820	384,924	5,243,744	5.06
1972	73.4	54.9	7.5	2.1	5,322,947	465,470	5,788,417	5.58

Source of basic data: US-AID, Project ADAM, "HYV in the Philippines: Progress of Seed-Fertilizer Revolution", Preliminary Report, Manila, Philippines, Dec. 1973

*Computations were based on the five-year average yield increase of 5.54 cavans per hectare for the irrigated areas and 0.56 cavans per hectare for the rainfed areas; and a constant 1968 hectarage of 1,309,020 irrigated hectares and 1,514,020 rainfed hectares. These hectarage figures were multiplied by the corresponding yearly percentages planted to new rice.

**These figures are based on total production from all areas: irrigated, rainfed and upland areas. The total production in 1968 was 103,700,000 cavans.

supply has shifted are relatively quite conservative. Based on the information from the integrated agricultural survey of the Bureau of Agricultural Economics in 1971-72 (See Appendix Table 1), the yield advantage of the new varieties ranged from 12 percent in rainfed areas to over 17 percent for the irrigated crops. Similarly, in areas where the new rice varieties are well adapted, they outyielded the traditional varieties by 26.5 percent, net of the payment for the added fertilizer applied to the new rice varieties (See Appendix Table 2).

7. Price and Income Elasticities of Demand for Rice

In a United Nations study, the income elasticity of demand for rice in the Philippines was estimated at 0.4 for the period 1961-1963 (5, p.29). More recent estimates indicate that this might be too high. Using survey data, Aragon and Darrah reported lower figures (1). Another study seems to corroborate their estimates (10). The results reported by Sagun showed an expenditure elasticity of demand of 0.14 for rice producers and 0.09 for non-producers.[5/] For this reason and for the sake of completeness of the estimates relative to the needs of this paper, these later estimates were used in the analysis. As regards the price elasticity of demand no estimates are available by income class. Available estimates of the price elasticity ranged from a low of -0.30 to a high of -0.50 (7, p. 44). Both extremes were used in the calculation of the compensating variation in income.

5/ The expenditure elasticity of demand is greater/equal to/smaller than the income elasticity of demand as the marginal propensity is less/equal to/greater than the average propensity to consume. In the short run when the marginal is likely to be less than the average propensity to consume, the expenditure elasticity should provide an upper limit for the income elasticity of demand.

Table 2. Annual average income, rice consumption and income elasticity of demand for rice by income groups in the Philippines.

INCOME GROUP	LOW	MEDIUM	HIGH
Average Annual Income (pesos)	564.00	1275.00	2638.00
Annual Rice Consumption (kilograms)	101.10	104.70	112.30
Annual Rice Expenditure (pesos)*	154.68	160.19	171.82
Percent of Income Spent on Rice	27.42	12.56	6.51
Income Elasticity of Demand	0.07	0.04	0.04

Source of basic data: C. T. Aragon and L. B. Darrah, "Cereal Consumption Patterns", Staff Paper Series No. 115, Dept. of Ag. Econ., UPCA Los Banos, Laguna, Philippines, Dec. 1970.
*Based on an average rice price of 1.53 pesos per kilogram in 1970.

8. Present Value of Direct Benefits to Consumers

The direct benefits to a consumer in each income class were evaluated from the information above and summarized in Table 3. The compensating variation in income for the year 1972 was treated as an equilibrium amount of the annuity to the consumers for the succeeding years. This assumption raises some interesting issues. Is it reasonable to assume constant annual benefits from 1973 onwards? Will rice remain as important in Philippine diet 15-20 years hence as it is now? Answers to these questions presumably involve some predictions about future changes in consumer income and preferences as they relate to price and income elasticities of demand. Also, temporal changes in rice technology bear upon the assumption of a perpetual stream of annual benefits. The question is when these new varieties will be displaced by newer varieties. If technological change is predictable, the annual benefits from the new varieties can be cut off at the time a newer development renders them obsolete. However, varietal obsolescence occurs only if later development proceeds independently of current body of knowledge. As long as later technologies are more of an improvement of existing rice breeding techniques rather than entirely separate technologies, the benefits in Table 3 can be regarded as forthcoming from a series of rice varieties or more specifically from the present state of knowledge about rice breeding.[6/]

Table 3. Present value of the compensating variation in income which accrues to a representative consumer in each income group.

Income Level	1968	1969	1970	1971	1972	Future Annuity	Present Value*
			pesos (1970)/capita				
Case A: Price Elasticity = -0.30							
1) Low	13.30	23.76	24.80	26.92	30.10	30.10	376.92
2) Medium	13.77	24.61	25.69	27.90	31.19	31.19	390.51
3) High	14.66	26.40	27.56	29.93	33.47	33.47	418.77
Case B; Price Elasticity = -0.50							
1) Low	8.18	13.43	14.48	15.53	17.65	17.65	220.48
2) Medium	8.48	13.91	14.99	16.09	18.45	18.45	229.69
3) High	9.02	14.92	16.08	17.26	19.62	19.62	244.88

*This is the present value of past (1968 to 1972) and future benefits evaluated at an assumed discount rate of 15% and t=0 for 1973.

The effect of subsequent development on the present value of benefits is less, the more independently and the later the technologies come about.

6/ In this case, the actual benefits would be even larger than estimated in Table 3.

At a high discount rate (such as the 15% rate assumed here), incorporating the refinements in methodology may not alter radically the present value of benefits reported in Table 3. Of course the appropriate discount rate may also vary over time as the economy develops. Again, the impact of changing price and income elasticities of demand on the present value of benefits increases with declining discount rates.

The results suggest that a consumer's gain varies inversely with the absolute magnitude of the price elasticity and directly with the amount of rice consumed.[7/] In relative terms such gain diminishes as income and rice expenditure go up. Taking the median class and using Sagun's estimates of expenditure elasticity (0.14 for producers and 0.09 for non-producers) in place of the income elasticity would show that the compensating variation is less for a rice consumer-producer. A producer realizes smaller improvement in real income when the price of rice declines since at least a part of his income is derived from the sale of rice.

Less than 100% of the rice area was planted to new varieties (Table 1). This ought to make us cautious in interpreting the estimates in Table 3. Strictly speaking, the consumer's gain from the new seed technology should be based on the new varieties' output only. To clarify

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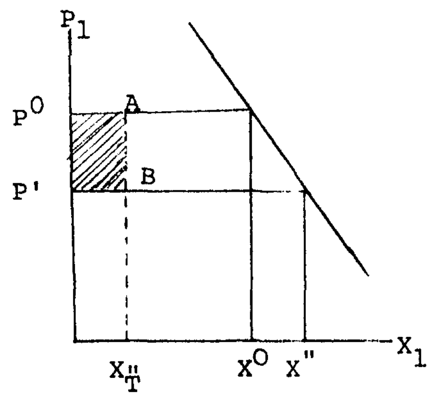
7/ Some clarification is in order here. Implicit in the calculation is that price adjusts to given quantity changes. Thus for increases in quantity, price falls proportionately faster if demand is more inelastic. If the causation is reversed, that is the price change is given and the change in equilibrium consumption is calculated, the corresponding gain would have been larger when demand is less inelastic.

this point let us postulate a typical consumer to whom the new and the old varieties are close substitutes and whose income compensated demand curve is illustrated below:



As rice price decreases from P^0 to P' consumption goes up from X^0 to X". Under the new price situation his rice consumption consists of X''_T of the old varieties and $(X''-X''_T)$ of the new rice.[8/] The fall in price for the old varieties multiplied by the amount consumed or the shaded area P^0ABP' represents a pure transfer from producers to consumers. It is still a part of consumer's gain but should not be construed as a benefit from the rice seed technology.

9. Rice Seed Technology and Foreign Exchange

The savings in foreign exchange due to the development of new varieties and the resulting change in the structure of foreign trade in

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8/ The proportion of X''_T to X" may range from zero to unity. So long as some amount of traditional varieties are grown, X''_T can not be zero for each and every consumer. Presumably the ratio of X''_T to X" is a function of income and consumer preferences.

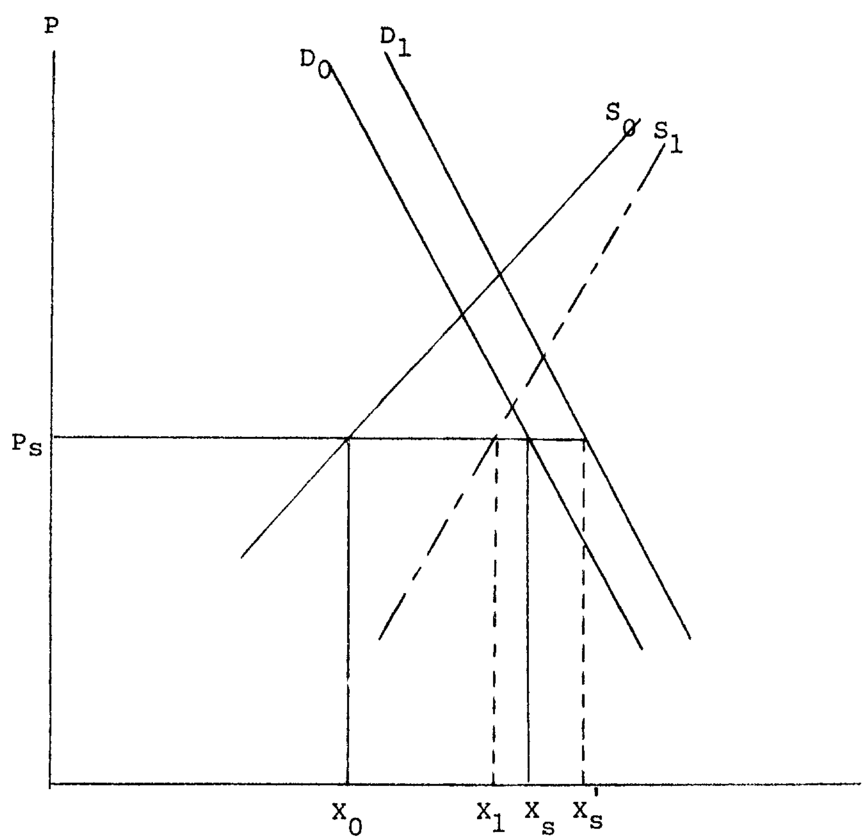
rice are additional benefits from the program. Changes in the domestic market price do not necessarily reflect the full social benefits from the technology. To the extent that new output substitutes for imports, rice price will not fall. In comparison the export benefits have somehow been implicitly accounted for in the compensating variation measure. Recall that the price declines were projected on the basis of total output. Had part of the new output been diverted to exports, the new price would have been higher than P' (See diagram in Section 8). In such an event the loss in consumer's compensating variation measures the opportunity cost of the foreign exchange. If the social value of export earnings generated is at least as great as the opportunity cost, then the latter does provide a minimum estimate of such benefits.

Except for a few years, the Philippines was a net rice importer up until the fiscal year 1968. The situation changed during the following year with a significant rice trade surplus. A series of deficits occurred again in 1971 through 1973, presumably due to unfavorable weather (12, p.7). That importation continued beyond 1968 is no indication that new varieties caused no import substitution. Aside from increasing demand, some circumstances make it difficult to measure the benefits from import substitution from the import/export record.[9/]

9/ I think Mangahas' criticism renders these data inappropriate for economic measurements of welfare. He stated: "For all practical purposes this import/export record is the result not of market forces but of government decisions solely, i.e. to accept this record as an indicator of self-sufficiency is likewise to accept that the government has had a generally accurate notion of the size of shortage or surplus .... (Given the method of estimating the shortage or surplus) ... there can be no guarantee that the error of estimate in I* (forecast of required imports) will be less than say 100%. Indeed, there can be no guarantee that we shall not commit the error of exporting when we should be importing or *vice versa*" (6, pp. 2-7).

But all is not lost. New varieties have certainly augmented rice production since 1968 despite lower yields in rainfed areas during 1970 and 1971 (Table 1). It is also true that domestic market price indicates the value of rice to consumers and the government reacts to price changes (6, p. 20). A natural conclusion follows. Rice imports would have been greater in the absence of the new seeds. Output of new varieties would have reduced or even eliminated rice imports had aggregate consumption been stagnant.

Insofar as the new varieties have economized on foreign exchange, it should be counted as a benefit. This is equivalent to the reduction in social costs of import expenditures. Let us resort again to a graphical representation of aggregate demand and supply.



If demand stagnates at D_0, maintaining a socially desirable price P_s implies additional imports equal to $(X_s - X_0)$ in the absence of additional production from new varieties. If demand increases to D_1, additional import needs are $(X'_s - X_s)$, in order to stabilize price at P_s. The implication in both cases is that new varieties reduced import needs to the extent that quantity supplied at P_s increased by an amount equivalent to $(X_1 - X_0)$. It may be more realistic to suppose that society desires not a constant P_s from year to year but a price increase at an acceptable rate as demand rises. Given the shift in supply as depicted graphically, there exists the possibility that import substitution from new varieties would decrease as P_s increases.

The benefit from import reduction can be estimated by means of a shadow price for foreign exchange saved. The shadow price depends upon the particular scheme used in financing imports; i.e. through credit, export expansion in other sectors, reduction of other imports, drawing from foreign exchange reserves, or some combination of them. This aspect presents a more difficult task and is therefore not empirically treated.

10. Effects on Income Distribution among Consumer Groups

The impact of the introduction of high-yielding rice technology on income distribution is a function of the distribution of the benefits as well as the nature of incidence on consumers of the costs of varietal development.

Section 8 shows increasing present value of benefits as income and rice consumption rise. But a given decline in rice price results in greater improvement in relative amounts in real income, the greater is the proportion of income spent on rice. Further, additional factors become important in relating the present value of benefits to the distributive effects of the rice program. One is the differences among various income groups in rice consumption patterns and another is household composition. Compared with lower income groups, high income homes consume mostly the higher premium traditional rice varieties. With increased availability of rice due to the seed technology, the consumption of lower income groups shifts to lower priced rice. They rate as the highest users of the new rice varieties (IR-5 and IR-8). Consumption patterns imply a relatively larger net compensating variation in income for the lower income groups than for the high income households.[10/] Further, the presence of domestic help accounts for the greater rice consumption in high income households (1, p. 10). Thus, even the benefits to this class is potentially shared with some low income people. Furthermore, there is a higher concentration of the population in the lower income brackets. As a group, the lower income people stand to gain larger absolute and relative benefits from the new rice seeds.

It is generally true that the expenditures of the Philippine government on the development and dissemination of the high-yielding varieties

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10/ The use of average price and elasticities aggregated over rice varieties (old and new) in Table 2 and in subsequent computations cannot reflect this. Although more detailed data are needed to demonstrate explicitly the asymmetrical effects, this result follows from the difference between income groups with regard to the magnitude of the purely transfer component of the compensating variation (See Section 7).

are underwritten out of general revenues. Under the present tax structure, consumers possessing the characteristics of the first two income categories are likely to be exempt from paying income tax. And it is a good guess that the income tax generated from the rural sector is proportionately smaller than the contribution of the rest of the population. Income in kind in the rural areas is less liable to taxation compared with the monetary income of salaried employees and wage earners from which income tax is probably withheld.

It is therefore plausible to infer that the new rice seed technology has resulted in income transfers among the broad groups in favor of the lower income consumers. Within a given income group, it seems that the bias is in favor of the non-producers. However, there is an element of uncertainty in this latter statement as it is possible that a producer has contributed a smaller proportion of the expenditure on the development of the new rice.

11. Concluding Comments

There remains the problem of extending the compensating variation measure to an aggregate dimension. Theoretical issues, e.g. interpersonal utility comparisons, preclude simple measurement of income compensation on the basis of aggregate demand curves. My view is that it might be less complicated to aggregate individual consumers' gains, weighted by the distribution of rice eating population among the various income categories.

The externalities generated by a major public program are usually extensive especially when some of the resources in the economy are less than fully employed. Any comprehensive study should try to measure these external effects of the new rice technology on employment in the agricultural sector, on its linkages with factor markets and other agribusiness industries, and on the technology-generating sector. Its impact on the production of substitute commodities and the changes in product use needs to be incorporated into the analysis. Consider the example of rice and corn. As relative price of rice drops, a substitution of rice for corn occurs in many areas in the Philippines.[11/] Assuming no shifts in hectarage from corn to rice, this substitution can possibly release corn stocks for industrial use and increase the load factor in corn starch and feedmilling industries. The society gains from the added efficiency by using what would otherwise be excess capacities.[12/]

Further, one can foresee more benefits from the new rice varieties, benefits which are forthcoming as the constraints to the adoption and dissemination of the new rice and supporting technologies are eased or eliminated. The extent to which the availability of a high-yielding rice variety improves the effectiveness of subsequent but supportive programs should be accounted for.

11/ The cross price elasticity (based on Davao prices) is reported to be 0.357 and the corn eating population is about 20% (5,pp. 1-2).

12/ Apart from this, a more direct benefit results from the change in the demand for corn as food because of the high cross price elasticity. The simultaneous changes in the demand for corn and rice can also be handled by the compensating variation measure (8 , pp. 355-356).

All these complexities (in addition to those on the cost side) cannot be effectively handled by the partial approach in this paper, and thus leads us to conclude that rigorous evaluation of the rice program necessitates a more general-equilibrium type of benefit-cost model.

Appendix Table 1: Yield differential between the new and the traditional rice varieties at the farm level by seasons and by areas.

Average Fertilizer Expenditure	IRRIGATED AREA								RAINFED AREA			
	First Crop				Second Crop				First Crop			
	New Variety		Others		New Variety		Others		New Variety		Others	
	Yield	No. in Sample	Yield	No. in Sample	Yield	No. in Sample	Yield	No. in Sample	Yield	No. in Sample	Yield	No. in Sample
pesos/ha.	cavans/ha.		cavans/ha.		cavans/ha.		cavans/ha.		cavans/ha.		cavans/ha.	
0	46.7	130	45.1	121	49.2	138	43.2	89	36.4	141	33.6	221
10	58.8	27	45.4	14	42.4	19	44.5	5	46.6	8	33,7	37
20	53.1	29	43.3	23	44.6	23	36.0	11	45.0	13	37.6	65
30	61.6	30	41.2	15	52.4	17	56.3	9	42.8	18	35.5	39
40	55.6	18	45.2	25	49.1	14	44.7	4	53.5	8	32.7	27
50	59.4	18	49.8	19	59.0	21	40.6	6	40.7	16	42.7	25
60	62.2	25	54.7	7	46.5	13	48.1	4	49.1	19	46.7	20
70	54.8	17	50.7	10	59.9	15	48.1	5	46.5	9	41.6	8
80	54.7	11	54.5	9	58.9	15	-	-	50.6	5	47.0	9
90	66.8	11	45.0	7	70.2	9	-	-	53.0	6	37.6	6
100	61.9	8	-	-	37.8	4	58.8	4	58.2	6	58.6	12
110	74.8	4	72.3	3	64.2	5	-	-	45.3	1	62.6	1
120	80.7	23	66.3	10	69.3	25	55.7	4	51.8	9	48.2	15
Weighted average Yield	55.81		46.99		52.39		43.63		41.40		36.81	
Average Fertilizer Expense	33.99		22.62		35.00		17.15		25.09		23.30	

Net Yield Increase* 17.8% for irrigated first crop; 17.5% for irrigated second crop; 12.2% for rainfed.

*Based on a rough rice price of 16.00 pesos per cavan

SOURCE OF DATA: US-AID Project ADAM, "HYV in the Philippines: Progress of Seed-Fertilizer Revolution", Preliminary Report, Manila, Philippines, December 1973.

Appendix Table 2: Increase in yield and nitrogen use due to modern rice variety in selected villages by season and type of farming.

	Yield of Local Varieties tons/ha.	Increase in Yield due to New Rice tons/ha.	Increase in Fertilizer kg. N/ha.
WET SEASON			
Monoculture	2.6	0.4	11
Mixed Farming	2.9	1.7	58
DRY SEASON			
Monoculture	2.9	1.0	27
Mixed Farming	4.4	1.0	48
Total	12.8	4.1	144

Net increase in yield: 26.5% (based on fertilizer-rough rice price ratio of 4.86 to 1.

Source of Data: R. Barker and T. Anden, "Changes in Rice Farming in Selected Areas of Asia" International Rice Research Institute, Los Banos, Laguna (not yet dated).

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